Chapter 6.2
Laser safety and health

This could be you . . .

Following safe practices has paid off. JSC has no recorded laser incidents.

1. Applicability of this chapter

You are required to follow this chapter if you operate lasers or supervise anyone who operates lasers. At this time, laser pointers are exempted from the requirements of this chapter. (See JSC Safety Alert 99-009, "Safety Hazards of Laser Pointers.")

2. Laser classes

JSC uses the laser classes in ANSI Z136.1, "Safe Use of Lasers:"

a. Class 1: No-risk lasers aren't hazardous under normal operating conditions.

b. Class 2: Low-risk lasers are low-power lasers that are dangerous only if you stare at a direct beam for long periods of time.

c. Class 3A: Moderate-risk lasers that are too dangerous to view directly.

d. Class 3B: Moderate-risk lasers that are dangerous if you look at a direct or reflected beam.

e. Class 4: High-risk lasers could cause eye or skin injuries and fires.

3. Requirements for working with lasers

You shall follow these requirements when you operate any Class 3A, 3B, or 4 lasers:

a. Register all Class 3A, 3B, and 4 lasers on JSC Form 44B and get approval for use from the JSC Laser Safety Officer (LSO) at (281) 483-6726. The LSO may require that a person who has substantial laser training be designated as the area Laser Safety Officer for your area.

b. Follow ANSI Z136.1, ANSI Z136.2, ANSI Z136.6, 21 CFR 1040.10, "Laser products," and 21 CFR 1040.11, "Specific purposes of laser products."

c. Each Class 3A, 3B, or 4 laser shall have an approved JSC Form 44B from the LSO and the Radiation Safety Committee before you may operate it.

d. If you modify the laser, you shall submit a new JSC Form 44B for LSO approval.

e. Don't operate a laser unless you are certified to do so by the LSO.

f. Know the hazards and hazard controls of each laser you operate. You shall take other precautions if:
   1. The target material could vaporize into a toxic substance.
   2. The laser uses toxic dyes as a lasing medium.
   3. The laser components cause radiation such as x ray, ultraviolet, infrared, or radio frequency.
   4. The laser could reflect off a smooth surface; e.g., glass, metal, or glossy paint.

g. Lasers have high-voltage power supplies. Take precautions to avoid being shocked.

h. Operate lasers with a beam stop.

i. Don't exceed the maximum permissible exposure (MPE) values found in ANSI Z136.1.

j. Tell all visitors in your laser area who aren't certified operators what the laser hazards are and what safety requirements they need to follow. Visitors shall also:
   1. Be under the direct supervision of at least one certified operator.
   2. Wear required protective equipment.

k. Operate Class 3A, 3B, and 4 lasers only in areas with:
   1. No unplanned reflecting or transmitting surfaces.
   2. Emergency lighting fixtures.
   3. Standard warning placards as described in ANSI Z136.1.

l. Keep all flammable materials away from laser areas unless specifically authorized by an operations or test plan.

4. Engineering controls for laser hazards

Each laser shall have hazard controls that meet ANSI Z136.1. Use engineering controls as much as possible. Also post a current copy of your operating procedures, when applicable. This table tells you which engineering controls are required for each laser class and when they are required. Next to each control is an ANSI Z136.1 paragraph number that offers more details. See the legend below the table for an explanation of the symbols.

Engineering Control Measure	Laser Class				
	1	***2***	***3A***	***3B***	***4***
Protective housing (4.3.1)	X	X	X	X	X
Without protective housing (4.3.1.1)	LSO must establish alternative controls				
Interlocks on protective housing (4.3.2)	**	**	**	X	X
Service access panel (4.3.3)	**	**	**	X	X
Key control (4.3.4)	---	---	---	#	X
Viewing portals (4.3.5.1)	---	MPE	MPE	MPE	MPE
Collecting optics (4.3.5.2)	MPE	MPE	MPE	MPE	MPE
Totally open beam path (4.3.6.1)	---	---	---	X NHZ	X NHZ
Limited open beam path (4.3.6.2)	---	---	---	X NHZ	X NHZ
Enclosed beam path (4.3.6.3)	None is required if 4.3.1 and 4.3.2 fulfilled				
Remote interlock connector (4.3.7)	---	---	---	#	X
Beam stop or attenuator (4.3.8)	---	---	---	#	X
Activation warning systems (4.3.9.4)	---	---	---	#	X
Emission delay (4.3.9.1)	---	---	---	---	X
Indoor laser controlled area (4.3.10)	---	---	---	X NHZ	X NHZ
Class 3B laser controlled area (4.3.10.1)	---	---	---	X	---
Class 4 laser controlled area (4.3.10.2)	---	---	---	---	X
Laser outdoor controls (4.3.11)	---	---	---	X NHZ	X NHZ
Laser in navigable airspace (4.3.11.2)	---	---	#	#	#
Temporary laser controlled area (4.3.12)	** MPE	** MPE	** MPE	---	---
Remote firing and monitoring (4.3.13)	---	---	---	---	#
Labels (4.3.14 and 4.3.7)	X	X	X	X	X
Area posting (4.3.9)	---	---	#	X NHZ	X NHZ

LEGEND: X – required; # – recommended; --- – not required; ** – required if embedded Class 3B or Class 4; MPE – required if MPE is exceeded; NHZ – nominal hazard zone (NHZ) analysis required; (4.3.5.2) – referenced paragraph from ANSI Z136.1-2000

5. Administrative controls for laser hazards

You may use administrative controls instead of or in addition to engineering controls as required by the LSO. Laser hazard controls shall meet ANSI Z136.1. Also post a current copy of your operating procedures, when applicable. This table tells you which administrative controls are required for each laser class and when. See the legend below the table for an explanation of the symbols.

Administrative Control Measures	**Laser Class**				
	1	***2***	***3A***	***3B***	***4***
Standard operating procedures (4.4.1)	---	---	---	#	X
Output emission limitations (4.4.2)	---	---	LSO determines		
Education and training (4.4.3)	---	#	#	X	X
Authorized personnel (4.4.4)	---	---	---	X	X
Alignment procedures (4.4.5)	---	X	X	X	X
Protective equipment (4.6)	---	---	---	#	X
Spectator control (4.4.6)	---	---	---	#	X
Service personnel (4.4.7)	** MPE	** MPE	** MPE	X	X
Demonstration with general public (4.5.1)	MPE (a)	X	X	X	X
Laser optical fiber systems (4.5.2)	MPE	MPE	MPE	X	X
Laser robotic installations (4.5.3)	---	---	---	X NHZ	X NHZ
Eye protection (4.6.2)	---	---	---	# MPE	X MPE
Protective windows (4.6.3)	---	---	---	X NHZ	X NHZ
Protective barriers and curtains (4.6.4)	---	---	---	#	#
Skin protection (4.6.6)	---	---	---	X MPE	X MPE
Other protective equipment (4.6.7)	Use may be required				
Warning signs and labels (4.7) (Design requirements)	---	#	#	X NHZ	X NHZ
Service and repairs (4.4.7)	LSO determines				
Modifications and laser systems (4.1.2)	LSO determines				

LEGEND: X – required; # – recommended; --- – not required; ** – required if embedded Class 3B or Class 4; MPE – required if MPE is exceeded; NHZ - NHZ analysis required; (a) – Applicable only to ultraviolet and infrared lasers (4.5.1.2); (4.4.5) – referenced paragraph from ANSI Z136.1-2000

6. Requirements for software that controls lasers

Software that controls lasers shall:

a. Provide safety precautions for fast moving-lasers and prevent misdirected lasers.

b. Undergo a hazard analysis as described in Chapter 2.4, "Hazard Analysis," of this handbook and NASA-STD-8719.13, "Software Safety."

7. Requirements for laser enclosures

In addition to laser enclosure requirements in paragraph 4 above, you shall:

a. Use flame-resistant materials or commercial products designed for laser enclosures to enclose Class 4 lasers. Laser levels above 10 watts per square centimeter could set the enclosure materials on fire.

b. Enclose high-pressure arc lamps and filament lamps or laser welding equipment in housings that can withstand the maximum pressure of a lamp explosion or disintegration.

c. Enclose laser targets and optical elements that could shatter during laser operation.

8. Protective equipment for operating a laser

If engineering controls don't eliminate the possibility of overexposure, you shall wear the following protective equipment:

a. Protective glasses or goggles designed to protect you from the laser you are using. Different lasers require different kinds of glasses or goggles. Make sure your protective glasses or goggles are on before you turn on the laser.

b. Skin protection as required.

Note: See ANSI Z136.1 for more details.

9. Training required for laser operations

The JSC Laser Safety Officer determines what, if any, training and experience is commensurate with the laser hazards accessible at each facility. The JSC Laser Safety Officer designates all Area Laser Safety Officers (ALSOs) and certifies all laser operators (LOs). Training Categories are:

a. *Laser operator* – The training and experience required for a certified LO may include, but is not necessarily limited to, the laser training topics as seen in ANSI Z136.1, "Safe Use of Lasers," Appendix D6.2 (1). LOs are required to have initial and refresher

training every 2 years thereafter. Training will be documented and maintained by the LO and the JSC LSO. A card will be issued for each laser operator certified by the JSC Laser Safety Officer.

b. *Area laser safety officer* – The training and experience required for an ALSO may include, but is not necessarily limited to, the laser training topics as seen in ANSI Z136.1, "Safe Use of Lasers," Appendix D6.2 (1) and (2). ALSOs are required to have an initial 40 hours of classroom training and refresher training every 2 years thereafter. Training will be documented and maintained by the ALSO and the JSC LSO.

c. *Peripheral personnel (janitors, security, firefighters, waste handlers, etc.)* – The ALSO and the LO are responsible for initial awareness-level laser safety training of peripheral personnel in their area such that they (peripheral personnel) understand the laser hazards associated with their work and are able to take appropriate actions to prevent unnecessary exposure. Awareness-level training shall be documented and a card issued for each person so trained by the JSC Laser Safety Officer. Refresher training is required every 3 years.

d. In addition to the above training categories and topics, you shall be certified to operate a laser as described in Chapter 5.8 of this handbook.

10. Emergency actions for laser mishaps

If laser mishap occurs, follow the emergency procedures in Chapter 3.8, "Emergency Preparedness," of this handbook and the emergency procedures for your facility. You shall contact the LSO as soon as possible to help you investigate the mishap.